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RADIUM

EDITED BY
CHARLES H. VIOL, Ph. D.
AND
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CONTENTS

A. E. Hayward Pinch, F. R. C. S. A Report of the Work Carried out at the Radium Institute, London, from Jan. 1st, 1919, to Dec. 31st, 1919. Part 1. - - - - - 69

REVIEWS AND ABSTRACTS

Channing C. Simmons, M.D. The Treatment of Carcinoma of the Skin with Radium. The Results of the Cases Treated at the Collis P. Huntington Memorial Hospital 82

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A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

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RADIUM

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY, PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

Edited and Published by Charles H. Viol, Ph. D., and William H. Cameron, M. D. with the assistance of collaborators working in the fields of Radiochemistry, Radioactivity and Radiumtherapy.

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VOL XV AUGUST, 1920 No. 5

A REPORT OF THE WORK CARRIED OUT AT THE RUDIUM INSTITUTE, LONDON,

FROM JANUARY 1ST, 1919, TO DECEMBER 31ST, 1919,

By

A. E. HAYWARD PINCH, F.R.C.S.

MEDICAL SUPERINTENDENT

The report of the work of the Radium Institute for the year 1919 is devoted principally to a detailed consideration of radium salt and radium emanation apparatus and their respective merits; to the question of screening and the elimination of "excited secondary rays;" to the modifications of technique; to the variations in dosage and exposure which different pathological conditions demand; to the stages of the reaction, its complications and sequelæ; to the local and general effects of radium irradiation upon radium workers, and to a description of the measures taken to minimise them.

A table of the new cases seen and treated between 1st January, and 31st December, 1919, and of the results obtained is given, and a general review of the diseases in which radium therapy is of value, with some indication as to the amount of benefit which may reasonably be anticipated in the various conditions.

Editors' Note—This Report will no doubt prove to be the most valuable of the many interesting reports which Mr. Pinch has made from year to year of the work at the Radium Institute in London, since he here gives, out of his long and wide experience in radiumtherapy, a summarizing statement regarding applicators, screens, technique, reaction, etc. In this issue is republished that part of the Report which deals with apparatus, screens, technique, reaction, sequellae, exposures, the effects of radium radiation on radium workers and the protection of radium workers. In the next issue will be republished that portion of the Report which deals with the treatment of disease.

TABLE I.

Classification of Cases.

Disease.	Examined, but not treated.	Recent report not received.	Received prophylactic irradiation only	Apparently cured.	Cured.	Improved.	Not improved.	Abandoned treatment.	Dead.	Total.
Carcinoma, Squamous-celled:										
Glabrous skin.....	5	1	5	—	—	3	2	—	—	16
Buccal, oral lingual, and pharyngeal mucous membrane	8	1	5	1	—	20	21	9	6	71
Œsophagus	4	2	—	—	—	1	2	—	1	10
Larynx	1	1	—	—	—	1	2	—	1	6
Vulva	1	2	1	—	—	1	2	—	1	8
Vagina	—	—	—	—	—	5	2	—	1	8
Uterus	5	12	2	—	—	31	16	7	3	76
Penis	—	1	—	—	—	—	—	—	—	1
Urethra	—	—	—	—	—	1	—	—	—	1
Bladder	—	2	2	—	—	3	2	—	—	13
Conjunctiva	—	—	—	1	—	—	—	—	—	1
Carcinoma, Spheroidal-celled:										
Breast	7	12	5	2	—	50	13	2	4	95
Thyroid	1	—	—	—	—	1	—	—	—	2
Liver	—	2	—	—	—	—	—	—	—	2
Carcinoma, Columnar-celled:										
Large intestine....	—	—	—	—	—	3	—	—	—	3
Rectum	4	4	—	—	—	20	6	1	3	38
Stomach	—	—	—	—	—	1	1	—	—	2
Ovary	—	—	—	—	—	1	3	—	2	6
Prostate	—	2	—	—	—	3	—	—	—	5
Rodent ulcer	1	10	—	80	—	30	3	3	1	128
Sarcomata	5	4	9	3	—	27	5	1	—	54
Melanoma	3	1	1	—	—	1	2	—	1	9
Endothelioma	—	2	4	1	—	4	2	—	1	14
Malignant glands....	—	2	1	—	—	—	—	1	1	5
Mediastinal tumour	—	2	—	—	—	3	2	—	2	9
Abdominal tumour ..	2	1	—	—	—	—	1	—	1	5
Villous tumour of bladder	—	3	—	—	—	1	—	—	—	4
Adenoma (thyroid, etc.)	3	—	—	—	—	3	—	—	—	6

Disease.	Examined, but not treated.	Recent report not received.	Received prophylactic irradiation only	Apparently cured.	Cured.	Improved.	Not improved.	Abandoned treatment.	Dead.	Total.
Granuloma	1	—	—	2	—	—	1	—	—	4
Lymphadenoma	—	1	—	—	—	4	—	—	1	6
Fibroid disease of uterus	1	1	—	2	—	3	2	—	—	9
Leucoplakia	1	—	—	—	—	1	—	—	—	2
Nævi:										
Capillary	1	—	—	1	—	13	1	—	—	16
Cavernous	—	1	—	—	—	16	—	—	—	17
Moles, warts and papillomata	—	4	—	3	20	1	—	1	—	29
Tuberculosis:										
Skin	1	1	—	1	—	12	2	—	—	17
Glands	—	—	—	—	—	4	—	—	—	4
Bone	1	—	—	—	—	—	—	—	—	1
Spring catarrh.....	—	—	—	2	—	4	—	1	—	7
Chronic conjunctivitis	—	1	—	—	—	1	—	—	—	2
" metritis	—	—	—	—	—	2	—	—	—	2
" ulcerations ..	1	1	—	—	1	1	—	—	—	4
Keloid, etc.	2	5	—	—	1	21	—	—	—	29
Lupus erythematosus	1	—	—	—	—	3	—	—	—	4
Psoriasis	—	1	—	—	—	—	—	—	—	1
Pruritus	—	—	—	—	—	3	1	1	—	5
Chronic eczema	—	—	—	—	—	2	—	—	—	2
Lichenification	—	—	—	—	—	2	—	—	—	2
Xanthoma	—	—	—	2	—	1	—	—	—	3
Xerodermia pigmentosum	—	—	—	—	—	1	—	—	—	1
X-ray dermatitis	—	—	—	—	—	1	—	—	—	1
Splenic leucocythæmia	—	—	—	—	—	1	—	—	—	1
Erophthalmic goitre	—	1	—	—	—	2	1	—	—	4
Neuritis	—	2	—	—	—	—	—	—	—	2
Dupuytren's contraction	—	2	—	—	—	1	—	—	—	3
Arthritis deformans	3	11	—	—	—	10	5	—	—	29
Various	8	2	2	—	—	4	1	—	—	17
Totals.....	71	101	37	101	22	328	101	27	34	822

TABLE II.

Summary of Cases.

Examined but not treated	71
Recent report not received	101
Received prophylactic irradiation only	37
Apparently cured	101
Cured	22
Improved	328
Not improved	101
Abandoned treatment	27
Died	34
Total	822

7,162 treatments were administered during the year, of which 4,497 were given free of all charge to necessitous patients.

771 emanation applicators were prepared during the year; of these 404 were distributed gratuitously to hospitals and medical practitioners.

Radium may be used for the treatment of disease either in the form of radium salts or radium emanation, the therapeutic effects being identical.

Both radium salts and radium emanation emit three kinds of rays: the alpha, the beta, and the gamma.

The alpha rays are particulate; that is to say, they consist of actual particles emitted from the source. These particles have been shown to consist of positively charged atoms of helium projected with a velocity of about one-fifteenth the velocity of light. They can be deflected by intense magnetic or electric fields. They are very readily absorbed by thin metal, glass, paper, rubber, or a few centimetres of air. Their therapeutic power is so slight as to be negligible.

The beta rays are far more penetrating than the alpha, and consist of negatively charged bodies projected with velocities of the same order as the velocity of light. They vary considerably as to their velocities, and are distinguished by the terms "soft beta," "medium beta," and "hard beta." They are far more readily deflected than the alpha rays, and are in type identical with the cathode rays produced in a vacuum tube.

The gamma rays are extremely penetrating, and cannot be deflected by a magnetic or electric field. Their exact nature is still undetermined, but they are analogous in many respects to very penetrating Roentgen rays.

The Secondary or Excited Rays—The passage of gamma rays through metals is accompanied by the production of "secondary" or "excited" rays. These rays are capable of producing considerable surface irritation, and when heavy metal screens are used it is often necessary to absorb these rays so far as possible by the use of many layers of paper, lint, or rubber.

APPARATUS

(1) *Radium Salt.*—The strength of all apparatus of this class is expressed in terms of hydrated radium bromide, a salt the radium element content of which is 53.6 per cent. *

As this salt is deliquescent and unstable it is always converted into the insoluble sulphate before being fixed in apparatus.

(a) *Tubes.*—These are made from capillary glass tubing, and the

*Very important to bear in mind, since dosage in the U. S. is expressed in terms of milligrams of radium element. To so express results given in this report multiply the given figures by 0.536.—Ed.

contained radium sulphate is tightly packed to prevent any movement of the salt. Their length varies from 1.5 to 4 centimetres, and their diameter from 0.2 to 0.3 centimetres. The amounts most generally used are 25, 50 or 100 mgrs.

(b) *Applicators.*—Rectangular, square or circular. Their superficial area ranges from 1 to 30 square centimetres. They are made of three strengths:—

(1) "Full strength," containing 10 mgm. per square centimetre.
(2) "Half strength," containing 5 mgm. per square centimetre.
(3) "Quarter strength," containing 2.5 mgm. per square centimetre. *

These correspond roughly to the French classification of 2,000,000, 1,000,000 and 500,000 activities.

(2) *Radium Emanation.*—(a) *Tubes.*—These are made of capillary glass tubing and as the radium emanation can be condensed to a very great extent, it is possible to concentrate in them the unit of activity to an exceedingly high degree. The size may vary from a length of 0.3 to 2, 3, 4, 5 or even more centimetres, according to the character of the case in which they are employed.

(b) *Applicators.*—These are hollow receptacles made either of thin German silver or glass. The former are usually made of a similar shape to the radium salt applicators, with a flat surface, and either square, rectangular, or circular in shape. The glass containers, on the other hand, may be made spherical, conical, oval, pear-shaped, or of any form to meet the requirements of the particular case for which treatment is required.

The Radium Salt Applicators have one outstanding advantage over radium emanation apparatus, in that the emitted radioactivity is always constant over any length of time; and further, an apparatus when once made, if carefully handled, needs but very little attention beyond an occasional renewal of its varnish at six monthly or yearly intervals.

Radium Emanation Apparatus.—The objection most frequently raised to these forms of apparatus is the steady loss of value of radioactivity, due to decay of the emanation, but this may quite easily be provided for. The rate of decay of emanation is well known, the initial radioactivity being reduced to half in 3.85 days, and to one-fifth in 8.5 days. During the first twenty-four hours the emanation loses exactly 16 per cent. of its activity—2 per cent. every three hours. If due notice be taken of this fact, it is a perfectly simple matter to obtain an apparatus the mean activity of which for twenty-four hours would be practically equal to that of a similar applicator of known strength. Supposing, for the sake of example, it is desired to give an exposure of twenty-four hours' duration, with a tube the activity of which will be equal to that emitted by a 100 mgrs. of radium bromide; an emanation tube is made possessing an initial activity of between 109 and 110 mgrs., by the end of twenty-four hours it will have fallen in value to between 92 and 93 mgrs., so that its mean activity for the whole of the period will be as nearly as possible that of 100 mgrs.

Possibly the greatest advantage in the general use of radium emanation is the fact that its intrinsic worth is but slight, so that if an emanation apparatus should inadvertently be lost, no pecuniary loss is incurred beyond the value of the applicator and screens.

*These strengths are equivalent to 5.36, 2.68, and 1.34 mgr. of radium element respectively per sq. cm. and approximate the quantities of 5.0, 2.5 and 1.25 mgm. of radium element per sq. cm. used in the U. S.—Ed.

Screening

In the early days of radium therapy screens of various metals, and of thicknesses ranging from .01 mm. of aluminium to 3 mm. of platinum were employed. As the result of prolonged clinical experience, however, it has been found possible to reduce the number of these screens very considerably, without in any way interfering with the therapeutic effects, and the list has now been reduced to within very practical limits. It comprises:—

Aluminium, 0.01 to 0.2 mm. in thickness.
Silver, 0.2, 0.5, and 1 mm. in thickness.
Lead 0.1, 1.0, 1.5 and 2 mm. in thickness.
Platinum, 0.3 mm. in thickness.

With this range of screens almost any degree of filtration of the various beta and gamma rays can be obtained.

Absorption of the Beta and Gamma Rays from Radium by Various Metal Screens.

Screen.	Thickness in mm.	Percentage transmitted.	
		Beta	Gamma
Lead	0.1	23.6	99.5
	1.0	0.48	95.1
	2.0	0.37	92.8
	3.0	0.29	90.5
Platinum	0.3	2.28	97.2
Silver	0.2	16.3	99.1
Aluminum	0.5	3.98	97.1
	1.0	1.18	95.5
	0.01	96.3	99.99
	0.1	76.3	99.98
	0.2	63.2	99.78

The values for the beta rays are calculated from data given by Seitz (*Phys. Zeitschr.*, 1904, 5, 395). They are only approximate, as, owing to the complexity of the beta rays from radium, the co-efficient of absorption decreases as the thickness of the screen increases, the soft (low velocity) rays being absorbed first. Moreover the results may be complicated by the secondary beta radiation, excited by the gamma rays. This is especially likely to be the case with the 2.0 and 3.0 mm. lead screens.

The percentage transmissions of the gamma rays are obtained by using the values given by Rutherford ("Radio-active Substances," 1913, p. 264).

Possibly the best all-round screen for general use, as applied both to tubes and applicators, is 1 mm. of silver. Aluminium screening is only employed in the treatment of superficial and non-malignant cutaneous lesions. Silver screening is most useful when the actual burying of tubes within the substance of tumours is resorted to, but it also proves of peculiar value in the treatment of keloids and vicious cicatrices. Platinum is most generally useful as a screen to tiny but extremely powerful emanation tubes, which are buried in small malignant growths in the neighborhood of the mouth, fauces, and air passages, as the screening power of 0.3 mm. of platinum is about equivalent to that of 1 mm. of

silver. Lead screens of 2 mm. in thickness are employed as a matter of routine in the treatment of all those cases where radiation with the deeply penetrating gamma rays is required.

Special shapes of screens are often called for, particularly when it is desired to vary the character of the radiation that different portions of the same lesion shall receive.

The most useful of these are:—

(1) *"Window Screens.*—In the manufacture of these a leaden tube with walls 2 mm. in thickness is taken, and a window occupying one-third of its circumference cut in it. This gap is then closed with a screen of 0.1 mm. of lead, 0.5, or 1.0 mm. of silver, according to the nature of the surface treated. A tube of radium salt or radium emanation is then inserted into the tube, and the apparatus placed in the position which will permit the ulcerated or fungating portions of the growth to receive the lightly filtered radiation, and the remainder the heavily filtered rays.

(2) *"Sleeve" Screens.*—In these a silver tube, with walls of 0.5 or 1.0 mm. in thickness, is inserted in a collar or sleeve of lead 1.5 or 2.0 mm. in thickness, encircling half or two-thirds of the length of the silver tube.

(3) *"Hour-glass" Screens.*—Specially useful in the treatment of annular carcinomatous strictures of the rectum or œsophagus. Their shape ensures their retention in an accurate position throughout the exposure.

The passage of radium rays through thick screens of heavy metal gives rise to the production of "secondary excited rays"—reflected and emergent.

The emergent "secondary excited rays" are capable of causing considerable surface irritation, and for this reason it is necessary to absorb them. Hitherto this has been effected by the interposition of many sheets of black paper, with rubber and lint, between the outer surface of the metal screen and the skin of the patient. A series of investigations which has recently been carried out in the Research Laboratory of the Institute has, however, shown that the emergent "secondary rays" from a leaden screen 2 mm. in thickness, can be completely absorbed for all practical purposes by a layer of aluminium 0.2 mm. in thickness, and such leaden screens are now being made with this additional aluminium sheathing, which completely does away with the necessity for the use of paper and lint.

Technique

(a) *Flat Applicators.*—An apparatus should be selected of a size somewhat larger than the lesion to be treated. The surface of the lesion should be cleansed and dried, adherent crusts or discharge being removed, and the healthy skin and tissues immediately surrounding it should be protected by a layer of lead rubber sheeting similar to that used in x-ray work, an aperture being cut in the sheet the exact shape of, but rather larger than the lesion itself. The applicator, if used unscreened, should be covered with a layer of thin rubber sheeting, to protect it from contact with any moisture or discharge.

The apparatus is best fixed in position with some non-irritant adhesive rubber plaster, and a crepe Velpeau bandage over all.

(b) *Tubes.*—It is now a well-known axiom in radium therapy that whenever the burying of a tube in a growth is possible this method of

treatment should always be adopted, the reason being that the radiation from a radium tube is contrifugal in character, so that if embedded in the center of a mass the whole of its activity is effective. On the other hand, if merely laid upon the surface of a growth, but little more than 30 per cent. of its rays come into action.

The technique to be employed in the use of tubes varies very considerably according to the site of the disease. In growths affecting the ethmoidal region, nasal passages of naso-pharynx, it is often found of advantage to mount the tube on the end of a stiff but pliable silver wire, the tube being inserted into the requisite position; the free end of the wire is brought out at the nose or mouth, bent at an appropriate angle, and fastened on the cheek with strapping. This securely retains the apparatus in position for the necessary period of time.

Growths of the epiglottis, tongue and floor of the mouth demand the employment of the small platinum screened emanation tubes, and it is customary to affix a silken thread to the stopper of these tubes, which is brought out at the angle of the mouth and fastened to the cheek with strapping, thus preventing the patient from swallowing the tube should it inadvertently become dislodged.

Dental modelling compound often proves of considerable value in retaining a tube accurately in position at the alveolar margin of the jaws. A mould of the affected area is first made, and removed from the mouth. A groove of the size sufficient to hold the radium tube is then made, the radium tube inserted, and the mould then replaced over the affected site.

Growths of the œsophagus. The insertion of radium tubes into these growths should always be done under a direct œsophagoscopy. The radium tube is mounted at the end of about twenty inches of pliable silver wire, which serves to guide the tube accurately into the lumen of the growth. The œsophageal tube being withdrawn, the pliable silver wire is moulded to the arch of the palate, brought out at the mouth, and securely fastened to the cheek or jaw with strapping plaster.

In the few cases where an attempt was made to treat carcinoma of the pyloric end of the stomach, a silver screened emanation tube was employed, and fastened to the end of a strong silken thread, two split B.B. shot then being affixed to the silk at a distance of 1 and 2 centimetres from the end of the tube. The tube, with attached silken thread and shot,was then swallowed, and its position in, and progress through, the stomach to the pylorus duly noted by means of the x-ray screen. The dense shadow thrown by the shot is very readily seen, and helps to locate the position of the silver screened emanation tube.

In the tube treatment of growths of the rectum a pliable silver wire is always used, and the tube passed into accurate apposition with the growth through a proctoscope, the wire being bent at the anal orifice, and fastened to the back of the sacrum with strapping.

If the growth be situate above the recto-sigmoid junction it is advisable to perform a colostomy, and to pass the tube down to the growth through the lower colostomy opening.

When dealing with malignant diseases of the body of the uterus, cervix or vaginal walls, the employment of a pliable silver wire is rarely necessary, as the tube can be introduced accurately through a speculum, and maintained in an effective position by packing with gauze or a tampon.

In cases of carcinoma of the prostate the employment of a bicoude catheter is to be advocated, the radium tube being placed in the penultimate bend of the catheter.

The treatment of bladder growths may be undertaken either by the urethral route, in which case the employment of a gum elastic catheter—the radium tube being placed at its distal end—should be adopted; or if operative measures have been resorted to, and a supra-pubic opening exists, the tube may then be inserted through this opening, and mounted on a pliable silver wire, which will serve to maintain it at the desired site.

Reaction

All tissues when treated with radium respond to some fashion, but the nature and extent of the reaction is modified by several factors, the chief being:—

(1) *The apparatus, screening, and dosage employed.*

(2) *The nature of the tissue treated.*—Mucous surfaces are much more responsive than the glabrous skin, and in them the reaction appears earlier, is more definite, and lasts for a longer time. There is also some difference to be noted between dry and moist surfaces; for example, the axillæ and inguinal folds, vesication in these situations occurring more readily than elesewhere.

Tissues of a definitely pathological character—carcinomatous or sarcomatous— do not display the same resistance to radium rays as normal cells, and it is upon the proper and correct appreciation of this fact that successful radium therapy largely depends.

(3) *The condition of the Tissues treated.*—Tissues which have previously received much x-ray or ionization treatment, or have been subjected to the action of CO_2 snow, or cauterization, need to be treated with considerable care, and it is advisable to proceed very cautiously in these instances, as any slight over-dosage frequently results in extensive breaking down of the old scar tissue, the process extending far beyond the limits of the area over which the patient has to be treated.

The reaction in patients who suffer from locomotor ataxy, syringomyelia, paralysis, or any other disease affecting the functions of the tropic nerves, is often atypical and excessive.

A similar phenomenon is also observed in areas of which the trophic nerves have been destroyed by some previous injury, such as a burn or operation incision.

The elaborate and extensive dissection associated with the performance of Wertheim's hysterectomy appears seriously to impair the vitality of the pelvic tissues for some little time, so that exposures given within three or even six months of this operation must be very carefully considered.

(4) *The Extent of the Area treated.*—The reaction is dependent not only upon the strength of the applicator, but also upon its surface area. For example, the reaction from an applicator of "half strength" applied over an area of 6 square cm. for an hour varies but little in degree from that obtained from a "quarter strength" applicator, 16 square cm. in area, applied for a similar length of time.

(5) *Personal Idiosyncrasy.*—This is most important, and is often responsible for curiously puzzling results. Persons of a highly neurotic temperament are undoubtedly more susceptible than those of a phlegmatic type, and both the local and the systemic reactions are likely to be very much more profound in the former than in the latter class of cases. This phenomenon is especially well seen in the treatment of some uterine conditions, and the greatest caution should be exercised on the first occasion of treating a patient of the former type for menorrhagia, leucorrhœa,

and similar affections, and it is often advisable to start with about one-half the dose that would be given to the other class of patient.

Patients who suffer much from freckling, or exhibit an unusual degree of susceptibility to actinic rays, frequently develop marked pigmentation of any radium treated areas after a lapse of several months. For this reason it is advisable not to treat such cases too vigorously, or at too short an interval, more especially if the condition from which they are suffering be situate on exposed portions of the body.

The Nature of the Reaction

The reaction usually appears between the seventh and fifteenth days, and may vary in character from a slight erythema to a destructive ulceration. Four degrees may be clearly distinguished—

(1) Simple erythema.
(2) Erythema followed by desquamation.
(3) Vesication with superficial ulceration.
(4) Deep ulceration, generally followed by the formation of a definite "limpet-shell" like radium crust, beneath which repair takes place.

With some patients the time of reaction is much delayed; in a few cases the response is exceedingly prompt, and it is difficult, if not impossible, to say exactly why this should be. It is perhaps most noticeable in the treatment of capillary nævi, and of rectal diseases, variations in these two classes of cases being very great. In some cases of rectal trouble the reaction will take three weeks or even longer in appearing, will persist for a month or six weeks, and will not have disappeared until about three months from the date of the termination of the exposure.

The scars resulting from the radium treatment of rodent ulcers, superficial epitheliomata, and other lesions of like character, are peculiarly susceptible to changes of temperature, the patients often complaining of great discomfort when unusually hot or extremely cold air play upon them. The susceptibility generally returns to normal in three or four months, but in some cases it may persist for a year or even longer.

In addition to the local reaction to radium, where a large quantity of radium has been employed and prolonged exposures given, there is a quite definite systemic reaction. This is best seen in the treatment of lymphosarcomata, lymphadenoma and sarcomatous growths generally. It comes on about the fourth day after the termination of the treatment, and is evidenced by languor, nausea sometimes going on to sickness, and a slight rise of temperature to 100 or 101 degrees. These symptoms are no doubt due to auto-intoxication; their disappearance may generally be expedited by the judicious employment of laxatives and diuretics.

Similarly, in the treatment of cases of exophthalmic goitre the first effect of the treatment is often an exacerbation of all the symptoms, occasioned most probably by an increased influx of thyroid section into the blood stream.

Sequelae

Certain sequelæ of radium treatment occasionally make their appearance, and it is important to take precautions to avoid these so far as is practicable. Those most commonly observed are pigmentation and telangiectasis of radium treated areas, and as they are specially prone to occur in cases of cutaneous nævi their development is often extremely disconcerting. It would appear impossible to eliminate this risk, but increased clinical experience has shown that telangiectasis and pigmentation are most often seen when very well marked vesication occurred in

the treatment of the nævus, and it is often better to commence treatment with screening of not less than 0.1 mm. of lead, than to give exposures which will produce anything greater than a simple erythema.

The patients should be seen at, say, three monthly intervals, for at least two years after the termination of the treatment, and if any telangiectasis appear it should promptly be destroyed with a fine electric cautery. The pigmentation which is occasionally met with, may often be kept in check, sometimes removed, by the judicious application of a weak bi-chloride of mercury and glycerine lotion.

The frequent repetition of exposures with heavily screened applicators within cavities, will sooner or later induce a very considerable degree of a steadily progressive annular fibrosis, often necessitating regular dilatation with the finger or bougie. This condition is most generally seen in diseases affecting the vagina or rectum.

In a very few instances, some skin areas which have been subjected to numerous prolonged exposures become white, thickened, and parchment-like to the touch, the appearance presented being strongly suggestive of sclerodermia. The condition, however, shows no tendency to spread, and remains strictly confined to those areas which have been exposed to radiation.

A somewhat intractable superficial ulceration is occasionally noted over the surface of nævoid growths which have had prolonged treatment. The appearance of such ulceration is indicative of the need of interruption of the treatment for at least six months, or even longer, in order to enable the skin to resumè its normal character. Subsequent exposures have to be given with much caution, and at greatly prolonged intervals. This phenomenon is a somewhat uncommon one, and appears to be conditioned largely by personal idiosyncrasy.

Exposures

The length of exposure to radium rays may vary from three minutes to a hundred hours, these variations being dependent upon the nature of the lesion treated, and the character of the screening employed. For clinical purposes exposures may be roughly subdivided into:—

(1) Very short exposures, of from three to fifteen minutes' duration.

These are called for generally in the treatment of superficial cutaneous lesions, such as chronic eczema, lichenification, psoriasis, etc. "Half strength" applicators, unscreened, are generally employed, and in the few instances where screening is resorted to this should not exceed 0.01 mm. of aluminium.

(2) Moderate exposures, unscreened, from half an hour to one and a half hour's duration. Usually employed in the treatment of very superficial small capillary nævi, keratomata, warts, corns, papillomata, and the early stages of rodent ulcer. "Half" or "full strength" apparatus is used.

(3) Long exposures, unscreened, from one and a half to three hours' duration. These are resorted to when it is necessary to produce a definitely destructive reaction; as for example, in the treatment of hypertrophic or deeply ulcerated rodent ulcers, small localized epitheliomata, pigmented moles, etc. "Full strength" apparatus are usually employed.

(4) Moderate exposures, screened. The screening employed is either 0.1 mm. of lead, 0.5 mm. or 1 mm. of silver, and the conditions which demand this kind of treatment are cavernous nævi, keloids, vicious

cicatrices, flat superficial epitheliomata, indolent ulcers, and inflammatory induration of recent origin. "Half strength" applicators are most useful.

(5) Very prolonged exposures, screened. These are adopted when it is considered advisable to use only the gamma radiation. The screening should be not less than 1.5 mm. or 2 mm. of lead, the latter being the usual thickness. With apparatus screened in this fashion, prolonged exposures of twenty- thirty or forty hours or even longer are frequently given, though it is advisable to change the site of the apparatus at intervals of not more than twelve hours to minimize the tendency to the production of superficial vesication.

Tube Exposures.—Speaking in general terms, when radium salt or radium emanation tubes are actually buried in the substance of a tumour, screening of 1 mm. of silver is employed, and an exposure of twenty-four hours' duration given, but the strength of the tube and the length of the apparatus must be calculated in accordance with the dimensions of the growth.

There appears to be some difference in the response of growths of epiblastic as opposed to those of hypoblastic origin; the former appear to be more favourably influenced by a longer exposure with a smaller amount, the latter by a shorter exposure, with a larger quantity, *e.g.*, 100 mgrs. for twenty-four hours in the one case, 200 mgrs. for twelve hours in the other.

But little good results from the actual burying of a radium tube in the center of a very rapidly growing carcinomatous nodule, as the result is merely to increase the necrosis and degeneration which has already taken place from pressure at the center of the mass, and no attempt at repair results. It should, therefore, be directed to the periphery of the growth, and prolonged screened exposures given, in the hope of stimulating the formation of fibroplasts, and thus restricting the spread of the disease.

THE EFFECTS OF RADIUM RADIATION ON RADIUM WORKERS

Persons who habitually handle or are constantly in contact with radium rays may be affected in two ways:—

(1) *Local changes.*—The hands of those occupied in making up radium apparatus, fitting the necessary screens, and applying the apparatus to patients, exhibit characteristic changes after the lapse of a few months. The skin of the fingers becomes roughened, non-elastic, and suffers loss of tactile sense. Sensations of heat and cold are exaggerated, extremes of temperature being very badly borne. At a later stage, fissuring of the skin, with the development of small corns or warts, is noted. The nails become brittle, thickened, and their longitudinal striation is greatly exaggerated. It seems probable that the majority of these changes are due to the "secondary excited" rays, as they are not nearly so evident in laboratory workers, whose duties are to a large extent concerned with the production of glass apparatus containing emanation.

Some degree of protection from the "secondary" rays may be obtained by the habitual use of thick leather gloves whilst handling the apparatus, but it does not wholly remove the danger, and for this reason relays of workers should be employed, who take on the special duty for three months, and then rest for nine.

(2) *Systemic Changes.*—These are undoubtedly due to prolonged radiation with the gamma rays, and it is seen to a greater or less extent in all workers at the Radium Institute.

The most constant and trifling of these changes is the feeling of general fatigue and exhaustion from which all workers suffer to a greater or less degree at the end of the day, though some are much more susceptible than others. After a certain time, however, definite blood changes make their appearance. There is invariably a leucopœnia, the total number of white corpuscles falling below 4,000 per cubic millim., sometimes as low even as 1,000 per cubic millim. There is also a diminution of the number of the red blood corpuscles, though in the earlier stages this is to some extent compensated by an increase in the color index.

Many female workers show a peculiar susceptibility in respect of their menstrual functions. Menorrhagia is first noted, the periods then become irregular, and amenorrhœa results, and remains permanent so long as the worker continues at her employment, though the functions return to normal after a holiday of four to six months' duration.

THE PROTECTION OF RADIUM WORKERS

Measures taken for this purpose may be classified under two headings:'—

(a) Those for minimizing the local effects.
(b) Those for minimizing the general effects.

(a) The workers should always wear thick leather gloves. All apparatus should be handled whenever practicable with wooden or rubber handled forceps not less than one foot in length.

The requisite screen, and enveloping lint, and rubber if used, are placed in position, the apparatus is then lifted with the forceps, dropped into the screen, the investing rubber brought to the neck of the apparatus, and rapidly tied with silk or thread. The apparatus is then removed with the forceps and placed at some distance from the worker, in a specially provided leaden receptacle.

When treating extensive diseased surfaces—as for example, recurrent carcinoma of the breast, lymphadenoma, lymphosarcoma, etc.—the handling of the apparatus may be greatly reduced by the use of specially made bandages which contain small pockets into which the apparatus can be dropped. The bandages are first applied to the patient's skin, in such fashion that the pockets come over those sites at which it is desirable that the exposure should be given. The prepared apparatus is then taken with the forceps, dropped into these pockets, and secured there with the aid of one or more safety-pins.

When this method of treatment is not possible, long strips of rubber adhesive plaster are employed, the nurse or attendant taking particular care to keep their hands as far from the radium apparatus as is consistent with the correct fitting of the applicator.

It is highly essential, in fact imperative, that no nurse or attendant should be allowed to make up or habitually apply apparatus for a period of time exceeding three months. An equal or even longer period of rest should then be allowed to elapse. If this rule be strictly observed, and the precautions above indicated rigidly adhered to, the amount of local disturbance produced is but slight, and proves quite transient.

In this connection it is important to recognize one great advantage of radium emanation over radium salt applicators; the emanation is comparatively inert for about half an hour after its preparation, and during this time but little secondary radiation is induced.

(b) The general effects are undoubtedly procured by the prolonged action of small quantities of gamma rays, which sooner or later are re-

sponsible for a distinctly cumulative action. The protection from these gamma rays thus becomes a matter of supreme importance.

The radium apparatus when not in use should be kept in a leaden box with a closely fitting cover composed of lead of 4 or 5 cm. in thickness, and this receptacle should be placed in a room as far as possible from the radium workers.

When making up the apparatus the workers should sit at a table which is covered with lead 5 cm. in thickness, a leaden breast plate being affixed to the edge of the table, of such height as completely to cut off all emergent rays from the body and head of the workers.

The apparatus when ready for application to the patient is placed in a lead lined carrier, which depends from a sling of about two feet in length, and the nurse carries the apparatus in this sling from the making-up room to the patient, thus avoiding the impinging of the rays upon the abdominal or thoracic cavities.

The constant and effective ventilation of all rooms in which radium is kept or employed is most important, and the employment of exhaust fans thoroughly to accomplish this is to be advocated.

It appears necessary for the maintenance of the general bodily health, that those who habitually work with, or are brought much into contact with radium, be given at least two clear days' holiday per week, which they should be encouraged to spend as much as possible in the open air, in rural surroundings, as this procedure will do more to combat the tendency to anæmia than any other therapeutic measures.

The blood of all workers should be examined at monthly intervals, so that if any indication of leupopœnia or anæmia of marked degree be noted, they may be at once released from duty, and sent for a holiday of one, two or more months' duration. Similarly, careful note should be taken of any disturbance of the menstrual functions, and should such appear, immediate absence from radium work is imperatively demanded.

(To be concluded in the next number)

REVIEWS AND ABSTRACTS

Channing C. Simmons, M.D. (Boston). The Treatment of Carcinoma of the Skin with Radium. The Results of the Cases Treated at the Collis P. Huntington Memorial Hospital. (Boston M. & S. J., Vol. xxxi, No. 16, October 16, 1919). Abstracted Am. Jour. Roent. vii, 64-65, Jan., 1920.

"The policy has been not to use radium in all cases of malignant disease applying for treatment but to advise operation if it seems best in a given case. In certain of the milder cases in which the growth is favorably situated, operation gives a better immediate result and a greater hope of permanent cure. In another class of advanced cases operation, to remove the greater portion of the growth, followed by radium treatment, is the treatment of choice. Most of the cases are suitable for radium treatment and can be divided roughly into two classes—those in which a permanent cure is to be expected and those in which the disease is extensive and in which radium is used as a palliative measure to retard the rate of growth."

"Radium is particularly valuable in the treatment of skin cancer arising about the orbit. Less deformity of the lids results by the destruction of the growth in this manner than by operation, which can always be performed later if the radium treatment is unsuccessful."

"On the other hand, in some cases, especially where the growth is situated about the ear or on the cheek, operation, followed by a plastic flap or skin graft, gives a better result."

"A plastic operation for ectropion or deformity of the nose after the destruction of the growth by radium, but should not be attempted until all inflammatory reaction from the radium has subsided and sufficient time has elapsed to make the possibility of recurrence remote. Carcinoma arising on the tip of the ear responds very slowly to radium and operation is usually the treatment of choice, the resulting deformity being less noticeable than would be expected."

"All patients should be warned of the possible depilatory effects of the radium, as the beard, eyebrows, or eyelashes may be unavoidably destroyed. Treatment inside the buccal cavity even will frequently destroy the beard. In treating carcinoma in the region of orbit, they should also be warned of the probability of conjunctivitis. A Wassermann test should be taken in all cases in which there is the slightest suspicion of syphilis, as the clinical diagnosis differentiating between rodent ulcer and syphilis is at times difficult. It must not be forgotten, however, that carcinoma can arise in a syphilitic ulcer, or that the two conditions may be coexistent and have no relation to each other."

"It has been made a rule not to treat carcinoma of the lip with radium except in cases where operation is contraindicated on account of diabetes, high blood pressure, or the extent of the growth, as we consider operation the only proper treatment. We have seen cases in which a small carcinoma of the lip had been entirely destroyed by radium develop hopeless carcinoma in the glands of the neck a few months later. Keratosis of the lip, the precancerous condition, yields readily to radium, which is the treatment of choice."

"*Methods of Treatment.*—The actual method of applying the radium for treatment varied greatly as to the type, situation, and extent of the growth. The usual procedure in the small superficial tumors in accessible regions was to fasten the glass tube containing the emanation, which was in turn enclosed in a steel needle, to the top of a metal cone 1 cm. in height, the diameter of which was slightly larger than the growth. The cone has a broad flange on the bottom which protects the surrounding skin from the action of the rays. The cone with the radium attached was then fastened over the growth and allowed to remain in place for from one-half to two hours. The usual dose was from 20 to 50 millicuries, although heavier treatments have recently been used. In growths about the scalp or orbit, sheet lead was also used as a protection to prevent loss of hair or conjunctivitis, which, in spite of all precautions, often follows the treatment of carcinoma of the lids. The average small growth usually disappeared in from two to four treatments, often in one, but the resulting superficial ulcer heals slowly. After the first treatment, patients report once in two weeks for observation and further treatment, as necessary. We have found that the best method of treating the superficial ulcers is to instruct the patient to bathe them once or twice daily with a solution of peroxide and water, equal parts, and keep them covered with white vaseline or other bland ointment, on a piece of compress cloth."

"In the large superficial growths the steel needles containing the radium emanation were usually laid directly on the growth in a series around it a short distance inside the edge. The bare glass tubes are also, at times, used in a similar manner, or raised up one half cm. from the surface on a piece of gauze."

"Fungoid growths, where there was considerable tumor tissue, were often treated by imbedding the glass tube containing the emanation directly in the tumor and leaving in situ. One or more tubes containing from 5 to 12 millicuries were usually embedded in this manner."

"In large growths on the cheek which have involved the bone and infiltrated the antrum much may be accomplished by removing the tumor by operation with the knife, curette, and actual cautery. A tube of radium may be introduced into the cavity thus formed in the gauze packing at the time of operation and left in place for from twelve to forty-eight hours, depending on the amount used. The deformity following these operations on the upper jaw is surprisingly little, considering their extent. Further radium treatments are given as indicated. The same procedure may be followed after eventration of the orbit for cancer, or, if there is a chance of all the growth having been removed, the radium treatment may be delayed until a recurrence appears."

"All cases are requested to report at the hospital regularly for observation whether they need treatment or not. Cases which do not report are followed up at the end of six to twelve months from their last visit to determine their condition."

"The 259 cases, for convenience of study, were divided into the following groups: Cancer of eyelids and about the orbit, 52 cases; cancer of the nose, 79 cases; cancer of the cheek, 71 cases; cancer of the forehead, 27 cases; cancer about the ear, 24 cases; miscellaneous cancer (hands, feet, etc.) 6 cases."

"Of these cases 201 (77 per cent.) had previously received some form of treatment. In some the growth had been destroyed but had recurred, while in others treatment had had little or no effect. Many patients had drifted from one physician to another and had tried several different remedies. Many of the methods of treatment employed are well recognized and it must be borne in mind that we only saw the unsuccessful cases and have no means of judging the numbers cured. A list of the more common methods employed is given below:"

"X-ray	61	cases
Violet light	4	"
Finsen light	1	"
Radium	11	"
Electricity	3	"
Operation	67	"
Cautery	13	"
Freezing (liquid air, etc.)	6	"
Cancer pastes	27	"
Ointments	44	"
Treated by many remedies	49	"
No previous treatment	56	"
No data	2	"

END-RESULTS

No recurrence 1 year	8 cases	
No recurrence 2 years	14 cases	
No recurrence 3 years	51 cases	
No recurrence 4 years	22 cases	
Recurrent cases	26 cases	21.4%
Result unknown	3 cases	

(Of the 26 recurrent cases, 13 yielded readily to further light treatment)."

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